DOCUMENT RESUME

ED 248 100 SE 044 747

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TITLE Math and Science Teacher Shortages: Dilemmas Old and New.
PUB DATE 15 Apr 83
NOTE 17p.; An Address to The Council for Basic Education Conference "Math and Science; Where Are the Teachers?" (Washington, DC, April 15, 1983).
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Educational Philosophy; *Mathematics Education; *Mathematics Teachers; *Science Education; *Science Teachers; Speeches; *Teacher Characteristics; *Teacher Shortage

ABSTRACT

This presentation describes the problem of teacher shortages in mathematics and science, providing a brief overview and some background for subsequent discussions of possible activities, solutions, and strategies. Five views that shape the problem definition are first given: (1) individual teachers do make a difference; (2) to be effective, teachers must be masters of what they teach, and must find their subjects intensely intriguing; (3) solving the teacher shortage should be focused at all levels; (4) the problem is one of both quantity and quality; and (5) this is not a new problem. Then two reasons for the teacher shortages are discussed: the severe reduction in the number of newly trained persons entering teaching, and the large exodus of those in teaching. The decline in quality and the decreasing ability of the profession to attract academically able individuals are then explored in terms of social, demographic, and economic factors. What we know of the typical teacher is reviewed in terms of lower teacher-pupil ratios, better education, lowered regard for teaching, and experience. Finally, reasons for the concern about mathematics and science education are discussed. (MNS)

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An Address to
The Council for Basic Education Conference
Math and Science: Where are the teachers?
Washington, D.C.

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April 15, 1983

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Math and Science Teacher Shortages:
Dilemmas Old and New

I am very pleased to address this distinguished body today about math and science teacher shortages. You may be asking yourself what else can anyone possibly say about math and science, teachers and curriculum, and shortages and declining test scores. You know the data, you have read it, you have seen it, you have heard it, and for many of you, you have experienced it.

My task today is to lay out the problem in order to place all of our discussions which will go forward in the working sessions in context. We should not spend a long time describing the problem and very little time considering and debating possible strategies to address the current situation. This has been too common an occurance recently. And yet, how you define a problem clearly influences how you solve it. Thus, I would like to take the next twenty to thirty minutes to give a brief overview and to provide some background for your subsequent discussions of possible activities, solutions, and strategies to address the shortage of matn and science teachers.

Given the responsibility of defining the problem, however, I must be candid and share some personal views that shape my problem definition. The first, and perhaps the most important, is that individual teachers do make a difference. Now, for some of you that may seem an obvious statement. Yet students of educational research and history will know that this has

not always been a commonly held view. For me, one of the most important factors in the equation of learning is the teacher.

A second observation is that teachers, in order to be effective, must be masters of that which they teach. Again it seems obvious and yet I find in my work with teachers at both the elementary and the secondary level, a lack of basic understanding of their subject matter. Topics focusing on the manipulations of fractions and decimals, or even basic notions of place value and geometry are sometimes not clearly understood.

It is also extremely important for teachers to find the subjects that they teach intensely intriguing and exciting. Today, many older students think a teacher who shows enthusiasm and excitement about mathematics or science is "weird." For the younger students, say in grades 1, 2 and 3, biases about subjects may be more subtle, and yet just as significant. A brilliant mathematical topologist at Princeton University hinted at his love of mathematics when he recently noted in a Wall Street Journal interview, "There are millions of these really neat discoveries, and nearly everything is connected. That is what mathematics is all about!"

A third view I hold strongly is that our concern in solving the shortage of math and science teachers should be focused at all levels, not simply at the secondary or higher education level. To focus only at the secondary level to the exclusion of the elementary areas is myopic. Similarly short sighted is the view that we only need to increase the capacity of our graduate engineering schools. When only 1/3 of our high school seniors have taken

three years of mathematics and less than 25 percent of them have studied three years of science, it is quite possible that we could shore up our graduate programs by endowing professorships of engineering and not have an adequate supply of students to enter these programs. In addition, we should be aware that atitudes about and preferences for math and science peak in the intermediate grades and decline steadily there after.

Nevertheless, the focus of some discussions on the secondary level is understandable and predictable. Test score data, for example, from the National Assessment of Educational Progress basically tell us that nine year olds in mathematics and science are doing adequately, but the 17 year olds are not. Also it is easier to focus at the secondary level where there are fewer schools and there are departmentalized teachers of math, physics or chemistry. We certainly need to set priorities, but we must not assume the problems rest exclusively in grades 6-12. They do not. It is simply a more visible and accessible portion of the educational system.

A fourth view that may surprise you, particularly since we are discussing math and science teacher shortages, is that the problem is not simply an issue of numerical supply. Indeed, we face both a quantitative and a qualitative problem. If, for example, by some divine intervention we suddenly had an infusion of 25,000 new math and science teachers--roughly a ten percent increase above present levels--the current condition of math and science education would certainly be improved, but the situation not solved. The math and science teacher shortage is not only measured in bodies--it is a shortage of quality too.

Finally, in my view this is not a new problem. We may see it more clearly today than five or ten years ago but, indeed, the issues of this conference including teacher training and renewal, financial incentives, the role of business and education, and computers are not new topics. We see the problem more clearly today for some interesting reasons which I will discuss, but the issues are not new.

Having stated these premises, let me now paint with broad strokes the situation we are in today. You know the basic tune--you can hum along. Teacher shortages in mathematics and science are created by two factors: first, the severe reduction in the number of newly trained individuals entering the teaching profession, and second a large exodus of thos currently teaching in those fields to other noneducational fields. As the teacher shortages of the 1960's gave way to surpluses of the 1970's, and as career opportunities expanded for women and those with technical aptitudes, the numbers preparing to teach math and science dropped dramatically. In the period from 1971 to 1980, a survey of 600 colleges and universities with teacher training programs revealed that there was a 64 percent decline in the number of secondary school science teachers being prepared and a 78 percent drop for mathematics teachers. On this issue of supply the 49 teacher training institutions in Massachusetts now report similar results to many other states in that, statewide, they will graduate only two students in 1983 who are prepared to teach chemistry and two to teach physics. Last year institutions in the state of New Hampshire graduated one student prepared to teach mathematics, while Connecticut produced 28 candidates for 161 vacancies.

It is important to observe however, that the national figures frequently cited on teacher supply and demand are not uniformly distributed across state boundaries or school district lines. On the demand side of the equation, urban and rural districts have long had difficulty attracting qualified teachers. Some states, such as Massachusetts, are only beginning to feel the problem. For example, just two years ago Massachusetts math and science teachers were laid off as a result of Proposition 2½, a referendum forcing property tax reductions which severely affected schools. Between 1980 and 1981, there were 341 fewer (out of some 4000) math and science teachers employed in the state. Ironically, some of those laid off responded to advertisements placed in the Boston Globe by districts in the southwest. Although national data are useful, it is clear that the nature and scope of the problem differ greatly depending upon the school and its location. In fact, even today when I talk about the situation in Massachusetts with well-informed individuals, many are stunned to hear the specific numbers and to realize that there will be a shortage of math and science teachers in our state in the next two years.

Another factor exacerbating the shortage of qualified teachers for our classrooms is the exodus of technically trained teachers to other jobs. Nationally, one in four science teachers plans to leave teaching completely while a recent survey of mathematics and physics teachers identified an even greater exodus within my own state. A survey of middle and upper middle class suburbs in the Boston area indicated that, within the next two years,

six out of ten mathematics teachers hope to find other jobs outside of education, while 13 out of 19 physics teachers plan to leave teaching completely. Many of these individuals hope to enter the high tech corporations located in Massachusetts and New Hampshire.

The second component of the math and science teacher shortage is a shortage of quality. Quality is an important long term issue behind the immediate question of supply and demand. Gary Sykes, one of the leading researchers on teachers today, has frequently noted that teaching attracts the least academically able and seems to be losing whatever attraction it previously had. Notably, he also documents that the low academic ability of teachers is not a new phenomenon but appears to be a historical fact only intensified more recently. Although that description is clearly troubling, an even greater source of alarm is the indication that of those being prepared for teaching, the less able are more likely to get jobs as teachers and of that group, the less able are more likely to remain as teachers permanently. Thus, at each decision point the less able tend to stay. To be fair, I must note that studies establishing causal relationships between a teacher's academic ability and student achievement are inconclusive. Nevertheless, given the choice, I would personally prefer to have teachers with greater rather than lesser academic ability teaching my two children. I think there are good reasons to worry about both the quantity and the quality of the teacher work force.

What causes the decline in quantity and the decreasing ability of the profession to attract academically able individuals? I suggest three factors:

social, demographic and economic. To test social factors, let me ask you a direct question: Would you advise your son or daughter to go into teaching today? In 1969, 75 percent of those interviewed answered yes, while by 1980 the number had diminished to 48 percent. Declining enrollments coupled with tax limitation measures and an increasing concern about the financial underpinnings of education have eroded some of the support that teachers previously felt for their work. Some suggest that the decline of public confidence in teachers is due to increased union activities after 1965. Another influence affecting the societal position of teaching today is that there are simply more service sector jobs for individuals to select. No longer are the traditional fields of social work, nursing, and teaching the only areas in which one can serve. A third change in our society that affects the social status and respect for teachers is the increasing level of education attained by our population. To say that teachers were the least academically able of our college graduates in 1950 still placed them in a relatively unique group since less than 10 percent of the adult population over 25 possessed college degrees. By 1990, it is projected that one out of four adults will have a college degree.

The second cause for the quantitative decline often not considered in any real detail is demographic. A simple review of the census statistics indicates that the number of 19 to 25 year olds, those forming the traditional labor pool of beginning teachers, will decline by 25 percent in the next twelve years. This causes me to believe the bills pending in Congress

to forgive undergraduate student loans for the study of scientific education will be much less effective than the 1958 NDEA measure. The pool of talent is simply smaller. Another demographic and social factor is that women--who have traditionally subsidized the teaching profession--now have wider career opportunities. Both the women's movement and economic pressures on women to work have led to an expansion of career opportunities for college educated women in fields such as law, business and medicine. With this expansion, fewer able women are entering the teaching profession. In the past, college-educated women had very few acceptable alternatives to teaching. To give you some indication of these changes let me take a professional school such as the Harvard Business School. In 1969 out of a class of approximately 750 there were 12 women. But in 1982 out of a class of 750 there were 188 women, a more than 15 fold increase. Many of these women would have entered teaching had no other career options been available.

The third cause for the decline in quantity and the decreasing quality is perhaps the most frequently noted problem--economic incentives. Capable college graduates with scientific ability are finding that their aptitudes and training are worth far more in earning power in industry than in education. Starting salaries in computer or banking industries for technically trained individuals often rank between $25,000 and $30,000 while in 1982 the mean starting salary for new teachers with a master's degree in Massachusetts was $13,767. This range is so great that I place little faith in the often mentioned notions of salary differentials or bonus pay proposed by some. They represent

a necessary, but not a sufficient condition to attend to the current crisis. Not only are the starting salaries much lower in education, but opportunities to reach a high salary level after lengthy service are nonexistent. The average maximum scheduled salary of public school teachers in Massachusetts in 1981 was $24,000. This less than a two to one ratio between a top salary and the starting position differentiates the 15 to 20 year veteran from the rookie. Moreover, in the last ten years material benefits have actually eroded for teachers. For example, the salary purchasing power of teachers declined in real terms by more than $1,000 since 1972. In addition, declining enrollments and tax limitation measures have threatened the traditional job security of teachers. Reduction in Force or RIF clauses are often more hotly debated in contract negotiations than salary or class size issues.

Another factor that deters many individuals from entering or staying in the teaching profession is the egalitarian salary structure. Frequently the competent and the incompetent collect the same pay check. With little opportunity for advancement within the profession and few economic incentives for outstanding performance, teaching is, as Dan Lortie, a University of Chicago sociologist describes it, "careerless." In sum, the realities of social, demographic, and economic influences make teaching an unattractive profession.

Since our discussions today will focus on teachers, I thought it might be helpful to review quickly what we know of the typical teacher. An important first observation to make is that overall there are more teachers

today than there were in 1970. Although K-12 enrollments have declined some 15 percent since 1970, the total number of teachers rose from 2.06 million in 1970 to 2.16 million in 1980, causing the student teacher ratio to decline from 22.3 in 1970 to 19.0 in 1980. The number of mathematics teachers have declined very slightly while the number of students plummeted. In 1979 there were approximately 131,400 reported teaching mathematics while 134,200 were reported in 1970-1971. In effect many of these new teachers are the product of state mandates and the specializations that have occurred within our curriculum. But the public perception is that there are simply more of them and that means more money spent on fewer kids.

Another important characteristic of teachers today is that they are better educated if one measures "education" by degree level. For example, the percentage of the overall teacher workforce holding master's degrees has more than doubled from the 1961 levels of 23 percent to 49 percent. For mathematics and science teachers, their increased degree attainments are significant because of the federal support available for NSF institutes throughout the 1960's and early 1970's. I note the <u>early</u> 1970's, since results from a recent National Science Teacher Association survey suggest that little of this training has been completed recently: some 79 percent of these respondents have not completed a workshop or course in over ten years.

And yet, even with this increased level of degree attainment, the opinions of public school teachers toward their profession and their personal feelings of adequacy are depressing. For example, when asked if they had

it all to do over again, would they become a teacher, 53 percent of those responding in 1966 said absolutely yes, while 22 percent answered similiarly in 1981. With regard to their training, 21 percent of mathematics teachers and 42 percent of science teachers identified "inadequate preparation" as a significant problem in their teaching.

Additionally, the teacher workforce has developed a large middle aged pot belly or bulge over the past 15 to 20 years. In 1966, the number of teachers in the 30 to 49 year old age group represented some 40 percent of the workforce whereas today, this number has increased to 62 percent. And, as you know, the mean age of the science and math teaching force is 41 with some twelve years teaching experience. In the Boston area, it is rare to find a math or science teacher under 35 years of age.

What these numbers mean is that the teachers that we are talking about today are getting older, they have more than a dozen years teaching experience, they are making less money, they are better educated if one measures education by degree level and yet many feel inadequate and less than one in four would choose the career again. These individuals are typically at the the top of their salary schedules where incentives to either remain as teachers or to improve their practice are small.

The math and science teacher shortage did not suddenly come upon us in the last year. Even five years ago articles were being written in US News and World Report and Phi Delta Kappan about shortages in math

and science. Why, then, is it now in 1983 that we seem to see everywhere we turn that there is impending doom? Has the notion of a crisis simply caught the fancy of the media and subsequently the public and the government? In part, I think the increased visibility and publicity of this situation is due to the fact that the success of math and science education this time around has been wedded to the economic well-being of our nation. Let me explain this by taking you back a few years. For those of us concerned with math and science education, there is a poignant sense of deja vu.

In the 1950's, we heard concerns about the condition of American education from various quarters. Although the concern was relatively widespread, I think it is safe to say that the launching of Sputnik in 1957 galvanized these opinions. By 1958, Congress had acted and passed the National Defense Education Act, which was a significant effort to improve with federal funds the curriculum and teaching in our nation's schools. With Sputnik there was something you could see if you walked out your door and looked up in the sky. It was a small dot that moved slowly but nevertheless was identifiable and visible to everyone in the country regardless of political party, race, or economic condition. From this concrete point of reference, there developed a broad based consensus about the importance of math and science education which was directly linked to our nation's well being. And our nation's well being related directly to our defense and technological capabilities.

It is interesting to note, that this Council for Basic Education came into existence during this period of grave concern about American Education. I believe it was founded in 1956 and expressed a level of concern and responsibility for education then that we see it continuing today with this conference.

After a strong start in the 1960's which many would also describe as one containing significant false starts, the first marriage of math and science education and the nation's well-being began to falter. Afterall, some may have observed, the union did achieve one of its objectives--to place a man on the moon and demonstrate our technological competence. By the early 1970's, the consensus about the role and objectives of education in all areas had weakened. And, as the range of activities that schools undertook grew to include equal opportunity, bilingual programs, special education, and responses to other pressures brought on by special interest groups, the purposes of education got blurred. In addition, the growth of both school enrollments and financial support for education through the first half of the 1970's helped conceal any pressures to make hard decisions and choose priorities. During this period of time, education, to continue the analogy--a young divorcee--had a number of suitors. In fact, many look back now and say that schools were asked to do so much in the 1970's that there was little consensus about what they ought to be doing.

But as the ravages of the Vietnam war receeded and we began to focus on the worsening economy, math and science education once again had a

new suitor. This one was amazingly handsome and attractive. Just as we all looked in the 1957 sky and saw Sputnik, today we look at our paychecks, the unemployment lines, the home mortgage and banking interest rates and see a real, concrete, identifiable reason for concern. Math and science education now has found a new partner in marriage--the economy. Appropriately, however we should note Samuel Johnson's view of second marriages: "They are the triumph of hope over experience."

As an example of this newly formed union, let me share with you a recent comment by Albert Shanker, President of the American Federation of Teachers: he stated, "Our technological competence, the state of the economy and the nation's defense all are behind a new recognition that quality math and science education are important." Thus, the success of math and science education has once again been linked to a broadly based, commonly held, realistic partner--one that crosses political, geographic, social and racial boundaries. And this consensus over the importance of the economy transfers nicely into a concensus about the importance of math and science education. Unfortunately, it is only because of this linkage with the economy and not the intrinsic importance of math and science education that we are moved to act.

Is it a new problem? I think not. I think certain developments such as the decline in the smoke stack industries and the increasing view that ideas, problem solving skills, and human resources are of great importance today have only exacerbated and highlighted the situation.

Another important factor giving credence to a focus on math and science issues is the sheer size of the technical community. Some assert that, whether consciously or not, this community swings greater political, social and economic weight today than ever before. Clearly this is true if we measure its fraction of the labor force, and its contribution to the GNP. What we are seeing with the shortage of math and science teachers is only the tip of the iceberg. In fact, it may be only a harbinger of a more pervasive and alarming situation in the entire American educational system.

If you feel that I have presented a depressing picutre here, I must agree. On the other hand, I am heartened by the intention to begin to push beyond the definition of the problem and to work on solutions. We must find ways to attract highly qualified math and science teachers to the teaching field and we must find ways to sustain and improve those that are already there. In so doing, perhaps we will initiate the extremely difficult process of changing the fundamental structure of teaching and the delivery of education. The changes will not be easy nor will the solutions be simple. But, let us join together and begin.